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It would seem desirable that, for comparison, reference should have been made to the extended series of similar maps recently published by Schuchert, and also to the series by Willis; especially as the three sets of maps show very different conceptions of the ancient epicontinental seas.

This book is probably the most comprehensive, original and suggestive of any single volume in geology now printed.

H. L. Fairchild

The University of Rochester

Technical Mechanics. By Edward R. Maurer, Professor of Mechanics in the University of Wisconsin. Third edition, rewritten. New York, John Wiley and Sons, 1914.

Maurer's "Technical Mechanics," of which the first edition was published in 1903, has a recognized position among useful text-books for students of engineering. The reprints previous to the present or third edition contained few changes; but practically the whole book has now been rewritten. The aim of the author, however, remains unchanged, the words of the original preface describing the book as "a theoretical mechanics for students of engineering" being again used as applying to the present rewritten edition. It has been the author's object to "furnish an adequate course of instruction for students of engineering in one semester, five times per week." The recasting for the present work has involved not only changes in arrangement and form of presentation, but some changes in subject-matter, such as the omission of the chapter on attraction and stress and some amplification of rigid-body dynamics. The scope and order of the work are indicated by the chapter headings: Composition and resolution of forces; forces in equilibrium; simple structures; friction; center of gravity; suspended cables; rectilinear motion; curvilinear motion; translation and rotation; work, energy, power; momentum and impulse; two-dimensional motion; three-dimensional motion; appendices on theory of dimensions of units and moment of inertia of plane areas. Especially worthy of note are the twelve pages in the chapter on momentum and impulse devoted to a lucid explanation of gyroscopic action and its applications to the gyrocompass, the mono-rail car, the gyro-stabilizer for ships, and the self-steering torpedo. A wholly new collection of problems is given, most of which are collected at the end of the book, thus avoiding interruption of continuity of exposition in the text. The illustrations, more than 500 in number, are executed with notable care.

Those who know the original edition need not be told that the author's presentation is, with few if any exceptions, sound, and that a notable quality of his exposition is conciseness without sacrifice of logical accuracy or completeness. Some teachers may perhaps think the virtue of conciseness is at times carried so far as to make the book unduly difficult reading for the beginner. The many teachers who have successfully used previous editions will, however, undoubtedly find the rewritten work even more satisfactory.

In reviewing the first edition[1] of this book, the writer took occasion to discuss certain questions regarding the presentation of fundamental principles of dynamics. At the present time special interest attaches to Professor Maurer's presentation of principles because of his position as chairman of the committee on the teaching of mechanics appointed in 1913 by the S. P. E. E. The appointment of this committee seems to have been due largely to certain rather vigorous criticisms of current methods of presenting fundamental principles, especially the "fundamental equation of dynamics" and the definitions of units of force.

Professor Maurer uses the equation $F = ma$, but his explanation of it makes it seem subsidiary to the equation $F/W = a/g$, or $F = (W/g)a$; the latter equation being explained as a special case of $F/F' = a/a'$, where a, a' are the accelerations due to forces F, F' acting on the same body at different times. In order to pass from the equation $F = (W/g)a$ to the equation $F = ma$ (or $F = Kma$ if units are unrestricted) use is made of the fact that different bodies in the same locality are equally accelerated by gravity. In the view of the

[1] Science, Vol. XXI., p. 302.

present writer this procedure is not strictly sound as a scientific explanation of the equation $F = Kma$. The presence of the mass constant in the equation should rather be accepted as an ultimate part of the laws of motion, while the facts of gravity are wholly apart from those laws. This is in fact elsewhere recognized by the author in his apparent acceptance of Newton's laws (p. 155) as the scientific basis of dynamics.

Although Professor Maurer's procedure described above seems to lend some countenance to the position of those who call the equation $F/F' = a/a'$ the "fundamental equation of dynamics," it is not likely that he really accepts this view; probably his order of presentation was dictated by pedagogic considerations. An equation which results from comparing the effects of different forces *upon the same body* can not, of course, be regarded as a complete expression of the fundamental law of motion; it is equally important to compare the effects of forces *acting upon any different bodies.* This of necessity brings in the body-constant which most physicists call mass. If an equation is used which does not contain this quantity explicitly, it must be implicitly taken account of in the application.

As a matter of fact it is difficult to understand the antagonism which some critics have shown for the equation $F = ma$. The main alleged objection to it appears to be the fact that it requires units to be properly chosen; but this is true of most of the equations used to express physical laws or facts.[2] One who really understands the fundamental principle of dynamics will have no difficulty in understanding the equation $F = ma$, or in remembering that it implies that units are so defined that unit force acting on unit mass causes unit acceleration.

To the present writer it seems that the real meaning of the fundamental equation of dynamics is most clearly brought out by presenting it first in the form of a compound proportion,

$$\frac{a}{a'} = \frac{F}{F'} \cdot \frac{m'}{m},$$

in which a is the acceleration due to a force F acting on a mass m and a' the acceleration due to a force F' acting on a mass m'. From this it is easy to pass to the equation $F = Kma$ for any arbitrary set of units, and then by a certain choice of units to the equation most commonly used because simplest, $F = ma$. Substantially this method of presentation was given in the first edition of Professor Maurer's book, but seems to have been omitted from the present edition.

As regards units of force, Professor Maurer's practise is the usual one among engineers. For ordinary use the pound-force or kilogram-force is adopted as unit, with the explanation that although this unit varies with locality, the variation is so slight as ordinarily to be of no practical importance. Although remarking that the pound-force can be made definite by specifying a standard locality, the author does not urge the general adoption of such a standard unit, but follows common scientific usage in adopting a kinetic definition of the absolute unit of force. This definition is, of course, based upon the fundamental principle of which the equation $F = ma$ (or $F = Kma$) is an expression. This principle being assumed, it is possible to define the unit force as that force which would give some definite mass some definite acceleration; the common practise being to take as unit the force which gives the (arbitrarily chosen) unit mass the (arbitrarily chosen) unit acceleration,[3] thus

[2] It is true, for example, of the equation usually employed to express the law of gravitation. It is true also of the simple equation $A = L^2$, where A is the area of a square of side L. In fact it is not easy to cite equations practically used in applied mathematics of which it is not true. The only way to avoid the alleged objection is to throw every such equation into the form of a proportion.

[3] It is worthy of remark that the advocates of the adoption of a standard pound force, though ostensibly defining it as the weight of a pound body at a standard locality, in reality define it as the force which would give a pound body (meaning a body whose mass is a pound) the acceleration 32.1740 ft./sec². Thus the real definition is of the same kind as that of the dyne, and the standard pound-force is really a "kinetic" rather than a "gravity" unit.

reducing the fundamental equation to its simplest form $F = ma$. The author points out also that it is possible to vary the procedure by choosing arbitrarily the unit force and adopting a kinetic definition of the unit mass; and he uses the word "slug" to designate the mass to which the pound-force would give an acceleration of 1 ft./sec^2. His explanation of this matter seems to the writer to be entirely sound, as well as being an aid to the student in acquiring a clear understanding of the fundamental law.

The entire treatment of force and of the laws of motion is notably free from the vagueness which too often characterizes the exposition found in text-books. The words push and pull are freely used, and the fact is explicitly stated at the outset that every force is exerted *by* one body *upon* another body. The law of action and reaction is stated in the following words: "When one particle exerts a force upon another, then the latter exerts one upon the former; and the two forces are equal, colinear and opposite." Most of the difficulty that arises over this law is due to losing sight of some one or more of the facts that are here explicitly stated. If it is kept clearly in mind that an action and its reaction (*a*) always concern two bodies and only two and (*b*) never act upon the same body, there is little difficulty in avoiding the confusion that is often associated with such terms as "inertia-force" and "kinetic reaction."

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Principles of Electrical Measurements. By Arthur Whitmore Smith. New York: The McGraw-Hill Book Company, 1914. Pp. xiv + 343.

In a laboratory course, emphasis may be laid by one teacher on manipulation and details of apparatus and, by another, on the principles underlying the methods employed in making the measurements. Professor Smith does the latter and has developed a text that is suitable for classroom as well as laboratory. The book is written for the instruction of those who are beginning their course in electrical engineering or who desire a more complete understanding than is afforded in most elementary manuals. It shows thoroughness and care in its preparation. In addition to a discussion of subject-matter usual in a laboratory manual of this kind—as ammeter and voltmeter methods; use of the galvanometer, bridge and potentiometer; measurement of current, power, capacity and inductance; magnetic tests of iron and steel—the author includes chapters on electromagnetic induction, on the definition of the Maxwell and on alternating currents, which, while not essential for one only interested in the taking of readings, lead the student to a better understanding of the subject as a whole.

Frederick Bedell

A Manual of Bacteriology for Agricultural and Science Students. By Howard S. Read. Ginn & Co. $1.25.

This little manual of 179 pages contains a collection of experiments, descriptions of methods, formulæ for media and reagents, and other information of practical use in a bacteriological laboratory. It is intended as an outline of a course for students, but it would be quite difficult, indeed, practically impossible, in an ordinary laboratory, for a student to follow this course consecutively, since the experiments described follow each other in an order that, while logical for study, would be almost impractical to carry out in a laboratory class. As a result the student can not follow the course without very careful thought and selection of experiments on the part of the teacher. The book is therefore more valuable for a manual for reference than as a distinct course for students to follow. It contains large numbers of experiments, and if properly used can be made of great use as a foundation of a course in bacteriology. It is more complete, more up-to-date, and contains more of the recent additions to bacteriological methods than the other manuals which have been published in the last few years. It is made more valuable by having in addition to methods strictly bacteriological some which are especially designed for the study of yeasts, and of common molds. While the methods are